



Amendments to the Claims

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1. (Original) An electronically conducting fuel cell component comprising:
 - a) a porous metal flow field;
 - b) an intermediate layer bonded directly to the porous metal flow field; and
 - c) an electrode bonded directly to the intermediate layer.
 2. (Original) The fuel cell component of claim 1, wherein the porous flow field comprises a three-dimensional reticulated metal structure.
 3. (Original) The fuel cell component of claim 2, wherein the three-dimensional reticulated structure comprises porous copper, porous nickel, porous aluminum, porous titanium, or a porous aluminum-titanium alloy.
 4. (Original) The fuel cell component of claim 3, wherein the three-dimensional reticulated structure comprises porous nickel.
 5. (Original) The fuel cell component of claim 1, wherein the porous metal flow-field further comprises a protecting layer disposed on at least one surface thereof.
 6. (Original) The fuel cell component of claim 5, wherein the protecting layer comprises a metal or a metal oxide.
 7. (Original) The fuel cell component of claim 6, wherein the protecting layer comprises tin, copper, nickel, aluminum, titanium, or gold.
 8. (Original) The fuel cell component of claim 6, wherein the protecting layer comprises ruthenium oxide, titanium oxide, or tin oxide.
 9. (Original) The fuel cell component of claim 8, wherein the protecting layer comprises tin oxide.

10. (Original) The fuel cell component of claim 9, wherein the tin oxide layer is between about 1 and about 5 μm thick.

11. (Original) The fuel cell component of claim 10, wherein the tin oxide layer is between about 1 and about 2 μm thick.

12. (Presently Amended) The fuel cell component of claim 1, wherein the intermediate layer comprises a polymer and ~~high surface area~~ carbon particles.

13. (Original) The fuel cell component of claim 12, wherein the polymer comprises polytetrafluoroethylene, perfluoroethylene-perfluoropropylene copolymer, perfluoroalkoxy, or polyvanilidene fluoride.

14. (Original) The fuel cell component of claim 1, wherein the electrode comprises a polymer electrolyte and an electrocatalyst.

15. (Original) A method for making an electronically conducting fuel cell component comprising the steps of:

a) directly bonding an electrically conducting intermediate layer to a porous metal flow field; and

b) directly bonding an electrode to the intermediate layer.

16. (Presently Amended) The method of claim ~~46~~ 15, wherein the porous flow field comprises a three-dimensional reticulated metal structure.

17. (Original) The method of claim 16, wherein the three-dimensional reticulated structure comprises porous copper, porous nickel, porous aluminum, porous titanium, or a porous aluminum-titanium alloy.

18. (Original) The method of claim 17, wherein the three-dimensional reticulated structure comprises porous nickel.

19. (Presently Amended) The method of claim 46 15, wherein the porous metal flow-field further comprises a protecting layer disposed on at least one surface thereof.

20. (Original) The method of claim 19, wherein the protecting layer comprises a metal or a metal oxide.

21. (Original) The method of claim 20, wherein the protecting layer comprises tin, copper, nickel, aluminum, titanium, or gold.

22. (Original) The method of claim 20, wherein the protecting layer comprises ruthenium oxide, titanium oxide, or tin oxide.

23. (Original) The method of claim 22, wherein the protecting layer comprises tin oxide.

24. (Original) The method of claim 23, wherein the tin oxide layer is between about 1 and about 5 μm thick.

25. (Original) The method of claim 24, wherein the tin oxide layer is between about 1 and about 2 μm thick.

26. (Presently Amended) The method of claim 46 15, wherein the intermediate layer comprises a polymer and ~~high surface area~~ carbon particles.

27. (Original) The method of claim 26, wherein the polymer comprises poly-tetrafluoroethylene, perfluoroethylene-perfluoropropylene copolymer, perfluoroalkoxy, or polyvanilidene fluoride.

28. (Presently Amended) The method of claim 46 15, wherein the electrode comprises a polymer electrolyte and an electrocatalyst.

29. (New) The fuel cell component of claim 1, wherein the intermediate layer comprises a polymer and carbon black.

30. (New) The method of claim 15, wherein the intermediate layer comprises a polymer and carbon black.



Response to the Office Action

A. Discussion of the Amendments to the Claims.

Claims 12 and 26 were amended by removing the terms “high surface area.” As discussed under Heading B, this amendment does not alter the scope of the protection sought.

Claim 15 was amended to more specifically point out that the porous flow fields of the present invention are porous metal flow fields. Support for this amendment is found in the specification at page 18, line 22 through page 19, line 10.

Claims 16, 19, 26, and 28 were amended by changing the dependency of these claims from claim 16 to claim 15. This amendment is to correct an inadvertent mistake in the dependencies of the original claims.

Claims 29 and 30 were added by the present amendment. Support for these claims are found in the specification at page 19, lines 20-23.

B. Rejections under 35 U.S.C. § 112.

Claims 12, 13, 26, and 27 were rejected under 35 U.S.C. § 112, second paragraph, as allegedly being indefinite for failing to particularly point out and distinctly claim the subject matter which applicants regard as the invention. Specifically, the Examiner contends that the term “high” renders claims 12 and 26 indefinite. To facilitate prosecution, claims 12 and 26 have been amended by deleting “high surface area.” However, Applicants respectfully point out that this amendment does not change the scope of protection sought in any way. High surface area carbon particles are well known in the art and specific examples of high surface area carbon particles, namely carbon black, are given in the specification at page 16, lines 17-20, and page 19, lines 20-22. It is well within the ability of one of skill in the art to recognize the types of carbon particles that are suitable for the claimed invention, with or without the term “high surface area.”

C. Rejections under 35 U.S.C. § 103.

Claims 1-28 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,372,376, by Fronk et al. (Fronk) and further in view of U.S. Patent No. 6,024,848, by Dufner et al. (Dufner). Specifically, the Examiner alleges that Fronk teaches an electrically conducting fuel cell component comprising a metal flow field, an intermediate layer comprising a plurality of conductive particles dispersed through an acid-resistant polymer matrix, and a protective layer comprising nickel and other metal oxides. The Examiner states that the intermediate layer of Fronk is bonded to the flow field and that an electrode is bonded to the intermediate layer. The Examiner suggests that Fronk is different from the present claims only in that Fronk does not expressly disclose that the flow field is porous or that the protective layer comprises tin oxide and is 1 to 5 μm thick. The Examiner alleges that Dufner teaches these aspects. Specifically, the Examiner contends that Dufner employs porous plates to decrease the weight of the fuel cell. The Examiner also contends that Dufner teaches that it is well known in the art to employ tin oxide with a thickness of 0.1 to 1 μm to minimize excess accumulation of liquid water at the cathode. According to the Examiner, it would have been obvious to one of ordinary skill in the art to employ the porous flow fields of Dufner in the cell of Fronk to decrease weight of the cell to meet specific operating demands. The Examiner also alleges that it would have been obvious to one of ordinary skill in the art to employ a tin oxide coating on the flow field of Fronk, because Dufner teaches that a tin oxide coating minimizes excess accumulation of liquid water at the cathode. Applicants respectfully traverse.

Neither Fronk nor Dufner teach a porous metal flow field. The cited references do not teach every element of the presently claimed invention. Specifically, neither reference alone, nor the references in combination, teach *porous metal flow fields*.

As used in the art of fuel cell technology, the term flow field refers to the means by which reactants are delivered to the cell such that the reactants can contact the membrane electrode assembly (MEA). *See*, page 17, lines 3-14 of the present specification. As described in the present specification, conventional flow fields typically consist of serpentine grooves machined into plates. The reactant gasses are delivered via these serpentine grooves into contact with the MEA. As described below, both of the cited references teach serpentine grooves as a flow field. In contrast, the porous metal flow fields of the present invention obviates the need for serpentine grooves:

Porous metal flow fields according to the invention are an improvement over solid flow fields. The porous metal allows gas flow without mechanically cut grooves, has low weight per unit area, is electronically conductive and is relatively inexpensive.

Page 17, lines 15-17 of the present specification.

As the Examiner points out, Fronk does not expressly disclose porous flow fields. Importantly, Fronk does not need a porous flow field, because Fronk already utilizes conventional serpentine grooves as flow fields. These serpentine grooves are explicitly denoted as 66 in Figs. 2-5 of Fronk. One of skill in the art would therefore not be motivated to modify Fronk by using a porous flow field.

The Examiner alleges that it would have been obvious to one of skill in the art to employ the porous flow fields of Dufner in the cell of Fronk to decrease weight of the cell to meet specific operating demands. This reasoning is faulty for two reasons: 1) as discussed above, Fronk utilizes serpentine flow field and therefore would not benefit from using porous metal flow fields, and 2) Dufner itself does not teach porous metal flow field because Dufner also utilizes serpentine flow fields.

Fig. 2 of Dufner describes water transport plates 60 and 66, which are porous and preferably made of a carbon-carbon composite of graphite powder phenolic resins (i.e., not porous metal). *See*,

Dufner, col. 8, l. 66 – col. 9, l. 4. The water transport plates are porous so as to allow water produced at the MEA to transfer through the plates and collect at water feed channels **64A**, **64B**, **64C**, **70A**, **70B**, and **70C**. *See*, Dufner, col. 5, ll. 52-67.

The porous “water transport plates” of Dufner are not the same thing as the porous metal flow fields of the present invention. In fact, Dufner is similar to Fronk because Dufner also uses serpentine flow fields. The serpentine flow fields of Dufner are apparent in Fig. 2, where they are labeled **62** and **68** and referred to as “gas distribution networks.” One of skill in the art would recognize that this gas distribution network is analogous to the flow fields of Fronk, i.e., they are a system of machined grooves through which reactants are delivered to the MEA of the fuel cell. This is fundamentally different than the porous metal flow fields of the present invention, wherein gaseous reactants flow through the porous metal to the MEA.

The Examiner alleges that one of skill in the art would be motivated to use the porous materials of Dufner in order to decrease the weight of the device. The Examiner is correct that the porous metal flow fields of the present invention allow for an overall decrease in the weight of a fuel cell stack. However, this decrease in weight is not due only to the fact that a porous element is less dense than a comparable solid element. The decrease in weight is mostly due to the fact that the porous metal flow fields of the present invention allow layers to be bonded directly to the flow field, which enables the construction of a self-supporting “glued-up” fuel cell stack. The “glued-up” fuel cell stack is lighter in weight than conventional stacks because the self-supporting design eliminates the need for heavy tie-rods and endplates to sustain structural integrity of the fuel cell stack. *See*, page 26, lines 9-18 of the present specification. As explained further below, this “glued-up” stack design is not compatible with serpentine flow fields and therefore the design of Dufner would not

realize the same benefits as the presently claimed invention because Dufner uses serpentine flow fields.

The porous metal flow fields of the present invention do not employ serpentine grooves and therefore their surfaces are uniform and flat. Applying a bonded layer directly to the porous metal flow field achieves uniform coverage, similar to applying peanut butter to a slice of bread. Because there are no grooves in the surface of the porous metal flow field, the entire surface area contacts directly bonded layer. This uniform coverage has several advantages over the non-uniform coverage that would be caused by the presence of grooves on the surface. For example, uniform contact over the entire surface minimizes electrical contact resistance. Moreover, the strength of this contact allows an entire fuel cell to be constructed by directly bonding layer upon layer, wherein each layer is strong and uniform and therefore does not require heavy tie-rods and endplates to maintain structural integrity. This advantage of the present invention is discussed in the specification at page 26, lines 9 through 18.

These advantages are not realized by the cells demonstrated in the cited references. Referring to Fig. 2 of Dufner, it is clear that the area of contact between intermediate layer 46 and water transport plate 60 is significantly decreased by the presence of grooves 62. One of skill in the art would recognize that this design would require heavy tie-rods and endplates to maintain the structural integrity of a stack of the depicted cells. This is particularly true because the Dufner stack requires pressurization to move water through the water transport plates. Endplates are specifically depicted in Fig. 1 of Fronk, where they are labeled 10 and 12. Note that the elements of the Fronk stack include bolt-holes at each corner to accept tie rods for bolting up the stack. Also, serpentine flow fields are not compatible with directly bonded tacky layers because the tacky layers would tend to clog the serpentine grooves.

The Examiner also alleges that it would have been obvious to employ tin oxide on the flow field of Fronk because Dufner teaches that tin oxide minimizes excess accumulation of liquid water at the cathode. Applying tin oxide to a flow field of Fronk still would not arrive at the presently claimed invention because the flow field of Fronk is not a porous metal flow field. As described above, neither Fronk nor Dufner teach porous metal flow fields. Because the references do not teach every element of the present claims, Applicants respectfully request that the rejection under 35 U.S.C. § 103 be withdrawn.

The Examiner is invited to contact the undersigned patent agent to discuss any questions or comments relating to the present response or the present application. Please date stamp and return the accompanying postcard to evidence receipt of these documents.

Respectfully submitted,



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